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Choice of Remuneration Regime in Fisheries: The Case of Hawaii's Longline Fisheries

Quang Nguyen and PingSun Leung

One of the most prominent features of remuneration in Hawaii's longline fisheries industry has been the norm of share contract regimes. This paper investigates whether the use of the share contract regime is positively correlated to increased economic returns. The principal-agent framework is applied to develop a theoretical model for the remuneration choice. Empirical estimation is conducted using a switching regression model that accounts for the effects of certain vessel characteristics on revenue, depending on remuneration regime used (i.e., share contract or flat wage), as well as the potential selection bias in the vessels' contractual choice. Key findings from counterfactual simulations indicate: (a) a negative selection related to choosing share contracts, and (b) flat wage vessels would experience significantly higher revenues if they switched to share contracts. Thus, even though the labor market in Hawaii's longline fisheries relies upon foreign crew members, the results suggest that owners of flat wage vessels would benefit by applying share contracts to increase their revenues.

Key words: commercial fisheries, crew shares, Hawaii, incentive systems, labor contracts, lay system, longline fisheries, remuneration regime

Introduction

The choice of remuneration regime is a matter of great interest in the fisheries industry. There are two main remuneration regime types in fisheries: flat wage and share contract. Under the flat wage regime, each crew is paid a fixed salary as compensation per pay period (e.g., a monthly salary). In the share contract regime,¹ the crew receives a percentage of either the gross revenue or profit per fishing trip. One of the most distinguishing features of remuneration in fisheries has been the norm of the share contract regime. Alternative remuneration regimes, such as fixed wage,² can be found only in a few fleets around the world.

Studies have theoretically shown that the share contract regime is the optimal form of remuneration in fisheries (Sutinen, 1979; Plourde and Smith, 1989). However, there has been no empirical study to support this theory. Because fixed wage has been surfacing in some types of fisheries in recent years, a series of new research inquiries have emerged. For example, one is prompted to ask such questions as: Is the dominance of share remuneration coming

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¹ In this paper, we do not distinguish the various levels of share contracts. Specifically, as long as the crew receives a certain percentage of the revenue or profit, we consider this to be a "share contract" since details of the share contracts are unavailable in the case of Hawaii's longline fisheries.

² The terms "flat wage" and "fixed wage" are used interchangeably here.

to an end? Is the recent shift to fixed wage in some fisheries a result of changes in some environmental parameters, or has the use of share contracts been based on false beliefs all along?

In this study, we apply the principal-agent framework to develop a model for evaluating choice of remuneration regimes in fisheries. We show that fixed wage may be a better alternative to the share contract under certain conditions. We then use the Hawaii longline fisheries as a case study to shed some light on the empirical relationship between remuneration regime and economic returns in fisheries as well as to provide some explanations for the recent shift from share contract regime to flat rate regime in fisheries.

Literature Review on the Determinants of Remuneration Regime in Fisheries

Matthiasson (1997) has provided an excellent survey on remuneration practices in fisheries; his main conclusion is that the share contract regime has been the dominant remuneration system. Other forms of remuneration, such as fixed wage, have also been applied in some fisheries though they have been short-lived (Matthiasson, 1997; Sutinen, 1979). In addition to the share contract and fixed wage, there is yet another practice of remuneration in fisheries. Béné (1997), for instance, reports that the shrimp fishery in French Guyana has applied the piece rate contract to avoid mixing of labor shirking with quality bonuses to induce shrimp quality since 1985. Like fixed wage, this type of remuneration is relatively rare in fisheries.

Share contracts also have been the prevailing regime in the Hawaii longline fisheries until recent years. Azabou, Bouzaiane, and Nugent (1989) attribute this general predominance to the following:

- Share contracts generate incentives for the crew to exert optimal fishing effort.³
- Share contracts share risk between the owner and the crew.
- Share contracts use resources relatively better than fixed wage contracts, especially when taking into account the highly seasonal nature of fisheries.
- Share contracts encourage teamwork and cooperation, which improve fishing productivity.
- Share contracts combine the comparative advantages of owner and crew for a sharing of benefits. For instance, the owner may have better access to credit and to market opportunities, while the crew members may be better fishermen.

Platteau and Nugent (1992) summarize and examine the comparative vulnerabilities between fixed wage and share contract systems (see table 1). Clearly, the popularity of share contracts in fisheries can be attributed to the potential benefits from risk sharing and generating incentives.

The Roles of Incentives

Matthiasson (1997) has developed a theoretical model showing that a pure share contract regime motivates a crew to exert more effort than fixed wage or a combination of fixed wage

³ In terms of fishing effort, we are interested in labor input on the part of the crew, as opposed to the use of "effort" to mean a collective input in fishing.

Table 1. Comparative Vulnerability of Different Remuneration Systems

Type of Vulnerability	Fixed Wage	Share Contract
Labor shirking	Serious	Moderate
Asset management	Serious	Moderate
Output underreporting	Serious	Moderate
Input overreporting	Serious	Moderate
Quality shirking	Slight	Slight
Production risk	Borne by owner	Shared
Price risk	Borne by owner	Shared

Source: Adapted from Platteau and Nugent (1992).

and share contract regimes at every given wage level. This phenomenon can be attributed to incentives. First, it is very difficult for the owner to supervise the fishing operation while the vessel is out at sea unless the vessel is owner-operated. Moreover, even if it were possible, the cost of supervision would be very high. The hired captain, motivated by her share of the profit, would ensure the crew's industriousness. Second, a typical feature of fisheries is teamwork, whereby the amount of fish caught is determined by the effort of the entire crew; therefore, the marginal productivity of an individual fisherman can hardly be specified. A share contract gives the crew incentives to work for the common goal.

Risk Sharing

In addition to incentive, risk behavior also plays a role in the decision related to remuneration in fisheries. Platteau and Nugent (1992) point out that fishing is subject to three types of simultaneous risk: production risk, price risk, and asset risk. Production risk results from uncertainties in both weather and marine ecology. Price risk is due to volatile supply conditions. Asset risk arises from concern associated with loss of assets and human lives. Using share contracts can reduce the risk burden for both the vessel owner and crew. Consequently, share contracts reveal the risk-averse behavior of the owner or crew. Due to technological changes, the role of labor relative to fishing productivity has become less important. Expectedly, the simplicity advantage of fixed wage may overcome the risk-sharing effect of share contracts. Thus, fixed wage has become increasingly popular over time.

While risk sharing is the most cited explanation for the popularity of share contracts in fisheries, McConnell and Price (2006) note that a number of questions remain to be addressed. First, for the share system to have emerged purely as a means of spreading risk, it must be the case that vessel owners are more risk averse than fishermen. However, this method of risk diffusion might not be the only solution, as owners may choose to diversify their investments through different species, in different locations, and at different times. Second, despite the uncertainties and risks associated with fishing, not all owners choose to use share contract regimes.

Implications for Modeling Fishery Remuneration Choice

Share contracts serve two functions: (a) to diffuse risk, and (b) to motivate crews to exert high levels of effort without direct owner supervision. Nevertheless, most theoretical models

consider these two functions in isolation. Also, predictions from these two approaches are different. Sutinen (1979) assumes in his model that both the vessel owner and crew are risk averse, that all other means of risk transferring are too costly, and that the transaction costs are negligible. Under these assumptions, a rational owner will choose some degree of share contract because risk is diffused among the crew, which reduces the cost of risk bearing and provides a work incentive making it less costly to generate a high desired level of performance from the crew. In contrast, if transaction costs are significant, and if there exist other risk-shifting means, then the fixed wage may be optimal.

Sutinen (1979) also shows that share contracts result in a higher level of employment and production. The economic reasoning for this is that the risk-averse owner must earn an income sufficiently above what she would earn in alternative settings as compensation for bearing the risk. As expected, the owner chooses a risk-sharing alternative which minimizes the risk premium. In sharing risk, the owner would pay the crew members less than the amount it would cost her if she were able to bear that same risk herself. Accordingly, under a share contract regime, the unit cost of production is lower and output is higher compared to a fixed wage system. Plourde and Smith (1989) extend Sutinen's model by integrating an output market, biological equilibrium, and regulatory policy into their framework. They report that in regulated markets, a fixed wage scheme may be optimal, leading to higher returns for fisheries firms.

McConnell and Price (2006) point out that incentive mechanisms are just as widely accepted as the risk sharing-based model. Matthiasson (1999) develops a model for Icelandic fisheries where skippers are paid by share subject to an agreed minimum without sharing operating costs. His key finding is that fixed wage and share contracts may coexist as an incentive contract when strategy-dependent, skipper-specific costs are important. With regard to incentive mechanisms, the most relevant modeling technique is the principal-agent approach employed by McConnell and Price. In their model, there are two contracting parties: the vessel owner and the crew. The contract consists of two parameters specifying the share of ex post revenues and costs for the crew. The possibility that each crew member allocates his labor effort independently toward production is also considered. In other words, given the assumption of a stochastic resource stock, there is a potential team agency situation. Accordingly, remuneration systems based on incentive contracts offer an alternative rationale to the risk sharing contract. An interesting finding is that, for a given set of parameter values, a remuneration system could include fixed wages independent of effort levels and revenue as well as no cost sharing. Along the same line, Platteau and Nugent (1992) reviewed empirical studies and found that fixed wages are observed among vessels having difficulty attracting qualified captains. Also, flat wages are applied to the crew whose efforts can be easily observed and less directly affect the catch level.

A Model of Remuneration Choice in a Fishery

Our model differs from the models discussed above in the sense that it integrates both risk sharing and incentive into the analysis. The starting point of our theoretical model is the realization that effort level exerted by the crew is unverifiable due to uncontrollable factors (e.g., the fishing stock) in the production process. Accordingly, the principal-agent (PA) model is most appropriate in addressing the fisheries remuneration strategies. To our knowledge, the only previous study using the PA approach is McConnell and Price (2006).

According to principal-agent theory (as Acemoglu, 1999, points out) the contract is the mechanism designed to resolve the trade-off between incentive and insurance. The latter is closely related to risk behavior of economic agents. Incentive and risk behavior are also crucial in fisheries. Accordingly, we focus on developing a model that places particular emphasis on analyzing the integral relationship among incentive, effort, and risk behavior, as well as how this relationship leads to the remuneration decision. Our model is more general than the model developed by McConnell and Price in two respects. First, they consider only the case of a risk-neutral crew. Here, we examine all cases of risk behavior for both crew and owner. Second, we extend the McConnell-Price model by treating effort level as a continuous rather than a binary variable.

Model Setup

Our model consists of two parts: a representative crew member and the vessel owner. The vessel owner is the principal who designs a contract with the crew. It is noted that we consider a representative crew member rather than the entire crew to make the model tractable. This approach differs from the assumption that the crew acts as if it were making decisions collectively. FitzRoy and Kraft (1987) provide an example of a model where difference between collective and individual decision making is illuminated in a similar setting. If the effort level is observable, the contract consists of two components: (a) the effort level, and (b) the corresponding wage of the crew. More realistically, effort level is not observed and only the latter is the contract element.

The crew's effort level is denoted by a continuous variable, e and $e \in [e_L, e_H]$. Let $\pi(e, \varepsilon)$ be the profit which is a function of effort level and other unobserved factors. More specifically, following Mas-Colell, Whinston, and Green (1995), we assume the owner's profit relates to the crew's effort via the conditional probability density function $f(\pi|e)$. In other words, the owner's expected profit can be written as:

$$E(\pi|e) = \int \pi f(\pi|e) d\pi.$$

To make the model tractable, we consider the simple functional form,⁴ $\pi(e) = e + \varepsilon$, where ε represents all unobserved factors and is assumed to follow a normal distribution with mean of zero and variance of σ^2 [$N(0, \sigma^2)$]. It follows that

$$E(\pi|e) = \int \pi f(\pi|e) d\pi = e \quad \text{and} \quad \text{Var}(\pi|e) = \sigma^2.$$

Note that the owner is not able to perfectly derive effort level based on the realized profit due to random factor ε .

With respect to the crew's wage, the owner is assumed to offer a linear payment scheme in the form of $w(\pi) = \alpha + \beta\pi$, where β is the share ratio of profit for the crew. Notice that $w = \alpha$ as $\beta = 0$; thus, α can be considered a fixed wage level offered by the owner to the crew. In what follows, we first consider the conventional assumption of risk behavior between owner and crew.

⁴ As our editor pointed out, this is a simplified assumption. However, our main purpose in developing the theoretical model is to shed some light on the correlation between risk aversion and remuneration choice. To keep the model tractable and achieve interpretable results, we follow Mas-Colell, Whinston, and Green (1995) who suggested the above profit function.

Conventional Risk Assumptions: Risk-Neutral Owner and Risk-Averse Crew

First, like McConnell and Price (2006), we assume the owner is risk neutral given that she has more resources than the crew, and therefore can diversify investment easier. Her expected utility takes the form: $E(U^{owner}) = E[(\pi | e) - w(\pi)]$. In contrast, we follow the conventional assumption that the crew is risk averse. This assumption is considered standard in the literature (e.g., see Sutinen, 1979; Plourde and Smith, 1989; Matthiasson, 1999; McConnell and Price, 2006). More specifically, we assume the crew's expected utility takes the following form: $E(U^{crew}) = E(w) - \phi \text{Var}(w) - v(e)$, where $E(w)$ is the expected wage; ϕ is a parameter representing how risk averse the crew is; $\text{Var}(w)$ is variance in the wage level denoted by σ^2 ; and $v(e)$ is the disutility function associated with the crew's effort, such as fatigue experienced by the crew from strenuous fishing activities. Following standard convention, $v(e)$ is assumed to be strictly convex such that $v'(e) > 0$ and $v''(e) > 0$. The first assumption implies the value of discomfort increases as effort increases. The second assumption implies the value of discomfort increases at an increasing rate as effort increases.

Substituting the wage equation, $w(\pi) = \alpha + \beta\pi$, into the crew's expected utility expression, we have:

$$\begin{aligned} (1) \quad E(U^{crew}) &= E[\alpha + \beta(\pi | e) - \phi \text{Var}(\alpha + \beta\pi | e) - v(e)] \\ &= \alpha + \beta E(\pi | e) - \phi \beta^2 \text{Var}(\pi | e) - v(e) \\ &= \alpha + \beta E(e + \varepsilon) - \phi \beta^2 \text{Var}(e + \varepsilon) - v(e) \\ &= \alpha + \beta e - \phi \beta^2 \sigma^2 - v(e). \end{aligned}$$

Given the above notation, the owner is assumed to face the following programming model:

$$(2) \quad \text{Max}_{w(\pi)} E(U^{owner}) \equiv \int [(\pi - w(\pi))] f(\pi | e) d\pi = E(\pi | e) - E(w(\pi)).$$

This is equivalent to:

$$(3) \quad \text{Max}_{\alpha, \beta, e} E(U^{owner}) \equiv \text{Max} [E(\pi | e) - E(\alpha + \beta\pi | e)],$$

subject to the individual rationality condition: $EU^{crew} \geq \bar{U}$, where \bar{U} is the reservation utility level of the crew. Substituting EU^{crew} from (1), we have the following equivalent individual rationality condition:

$$(4) \quad \alpha + \beta e - \phi \beta^2 \sigma^2 - v(e) \geq \bar{U},$$

and the incentive compatibility condition:

$$(5) \quad e = \arg \max [E(U^{crew})] \equiv \arg \max [\alpha + \beta e - \phi \beta^2 \sigma^2 - v(e)].$$

The incentive compatibility condition means that given the contract (β^*, α^*) offered by the owner, the crew would best respond by exerting the effort level of e^* . The individual rationality (IR) expressed in equation (4) implies the crew member will accept the contract if and only if his utility gained from being employed by the owner is greater than his reservation utility. If it is not, he will choose an alternative job or elect to work in his home country, as in the case of a foreign crew member.

Model Solution

The first-order condition from (4) above gives $\beta^* = v'(e^*)$. This result has a very nice economic interpretation—namely, the marginal benefit of effort (β) is equal to its marginal cost [$v'(e)$]. Also, given $v''(e) > 0$, there is a one-to-one positive relation between β and e . The higher the effort level, the higher is the profit and vice versa. Note also that the owner can always make the individual rationality condition (4) binding. Thus, we have:

$$(6) \quad \alpha + \beta e - \phi \beta^2 \sigma^2 - v(e) = \bar{U}.$$

Substituting $\beta^* = v'(e^*)$ and solving for α^* , we have:

$$(7) \quad \alpha^* = v(e^*) + \phi v'(e^*)^2 \sigma^2 - v'(e^*) e^* + \bar{U}.$$

From equation (7) for α^* , we see that the higher the reservation utility level, the higher is the fixed portion of the crew's wage. In the context of vessels with foreign crews in Hawaii's longline fisheries, α^* is expected to be relatively small given the foreign crew members have a lower living standard in their home country.

Next, substituting α^* , β^* into (1) and solving the owner's expected utility maximization program with respect to e would yield the following:

$$(8) \quad \begin{aligned} \text{Max}_e E(U^{\text{owner}}) &\equiv \text{Max}_e E[\pi | e - E(\alpha + \beta \pi)] \\ &\equiv \text{Max}_e \left[E(\pi | e) - E\left\{ v(e) + \phi \sigma^2 v'(e)^2 - v'(e)e + \bar{U} \right\} - \beta E(\pi | e) \right] \\ &\equiv \text{Max}_e \left[e - v(e) - \phi \sigma^2 v'(e)^2 + v'(e)e - \bar{U} - v'(e)e \right] \\ &\equiv \text{Max}_e \left[e - v(e) - \phi \sigma^2 v'(e)^2 + v'(e)e - \bar{U} \right]. \end{aligned}$$

By the first-order condition with respect to e , we then have:

$$(9) \quad 1 - v'(e^*) - 2\phi \sigma^2 v'(e^*) v''(e^*) = 0.$$

Substituting $\beta^* = v'(e^*)$ and solving for β^* gives:

$$(10) \quad \beta^* = \frac{1}{1 + 2\phi \sigma^2 v''(e^*)}.$$

Equation (10) is the key finding of our theoretical model. From (10), we can see that $\beta^* \in (0, 1]$, which is expected since β is the proportion of profit given to the crew. Also, the larger the variance in the profit level, σ^2 , the smaller the share of profit will be given to the crew. This result is very relevant to fisheries where the profit level by trip fluctuates considerably due to a host of uncontrollable factors. In extreme cases, variation in the profit can be so great that the profit level $\pi = e + \varepsilon$ is largely determined by the unobserved factor ε . Accordingly, the owner finds it hard to tell which portion of the profit is determined by effort level. Consequently, she would prefer the fixed wage system (choosing $\beta = 0$). The risk parameter, ϕ , also plays an important role. The more risk averse the crew member, the lower will be his share of the profit. This finding is consistent with results reported by McConnell

and Price (2006). In the context of Hawaii, an increasing number of crew members are being hired from foreign countries. For these fishermen, fishing is their only source of income—used to support them and to remit earnings to family in their home country. Therefore, they are very much averse to risk. This factor, in addition to the large variation in profit, makes β even smaller. At some point, we can observe $\beta = 0$ as the case of a fixed wage system.

It is also interesting to examine the relationship between effort level and risk aversion. Eriksson, Teyssier, and Villevall (2006), in their economic experiment on the principal-agent model, conclude that more risk-averse participants exert less effort. From the first-order condition, $1 - v'(e^*) - 2\phi\sigma^2 v'(e^*)v''(e^*) = 0$, and applying the implicit function theorem we have:

$$(11) \quad \frac{de^*}{d\phi} = - \frac{2\sigma^2 v'(e^*)v''(e^*)}{v''(e^*) + 2\phi\sigma^2 [v''(e^*)^2 + v'(e^*)v'''(e^*)]}.$$

Thus, the sign of the relationship between effort and risk aversion depends on the sign of the third derivative of the effort disutility function $v'''(e)$. With respect to $v'''(e) > 0$ (e.g., the marginal disutility function of effort is convex), we observe a negative relationship between effort level and risk aversion. Being risk averse, the agent may be afraid that the cost of exerting more effort is greater than his increased share of the profit which depends on other uncontrollable factors.

General Case of Risk Behavior for the Owner and Crew

We now consider the most general case of risk behavior for the owner and the crew. In this case, not only the crew member but also the owner consider their respective net income $[\pi - w(\pi)]$ and variation in that income. Accordingly, the owner's expected utility can be written as:

$$(12) \quad E[U^{owner}] = \pi(e) - w(\pi) - \gamma \text{Var}[\pi(e) - w(\pi)],$$

where γ is the owner's level of risk aversion. Note that

$$\text{Var}[\pi(e) - w(\pi)] = \text{Var}[(1 - \beta)(\pi(e)) - \alpha] = \text{Var}[(1 - \beta)(e - \varepsilon) - \alpha] = (1 - \beta)^2 \sigma^2.$$

Therefore:

$$(13) \quad E[U^{owner}] = \pi(e) - w(\pi) - \gamma(1 - \beta)^2 \sigma^2.$$

The individual rationality and incentive compatibility conditions are the same as those for the case of a risk-neutral owner. Following similar analysis, we can show that the owner faces the following programming model:

$$(14) \quad \text{Max}_e E[U^{owner}] \equiv \text{Max}_e E \left[e - v(e) - \sigma^2 \left\{ \phi v'(e)^2 + \gamma(1 - v'(e))^2 \right\} \right].$$

By the first-order condition with respect to e , we have:

$$(15) \quad 1 - v'(e^*) - 2\sigma^2 \left[\phi v'(e^*)v''(e^*) - \gamma(1 - v'(e^*)v''(e^*)) \right] = 0.$$

Substituting $v'(e^*) = \beta^*$ and rearranging gives:

Table 2. Optimal Values of β Under Different Risk Behavior Scenarios

	Risk-Averse Owner	Risk-Neutral Owner
Risk-Averse Crew	$0 < \beta^*_{oc} < 1$	$0 < \beta^*_{oc} < \beta^*_c < 1$
Risk-Neutral Crew	$\beta^* = 1$	$\beta^* = 1$

Notes: β^*_{oc} corresponds to the case in which both the crew and owner are risk averse; β^*_c corresponds to the case in which only the crew is risk averse.

$$(16) \quad 1 + 2\gamma\sigma^2 v''(e^*) = \beta^* \left[1 + 2\phi\sigma^2 v''(e^*) + 2\gamma\sigma^2 v''(e^*) \right].$$

Thus,

$$(17) \quad \beta^* = \frac{1 + 2\gamma\sigma^2 v''(e^*)}{1 + 2\phi\sigma^2 v''(e^*) + 2\gamma\sigma^2 v''(e^*)}.$$

From (17), we have:

$$(18) \quad \frac{\partial \beta}{\partial \gamma} = \frac{2\gamma\sigma^2 v''(e^*)}{\left[1 + 2\phi\sigma^2 v''(e) + 2\gamma\sigma^2 v''(e^*) \right]^2} > 0.$$

In other words, the more risk averse is the owner, the more willing she would be to increase the share of profit to the crew. The case in which the crew is risk neutral (i.e., $\phi = 0$) is also of interest. Here, we have $\beta^* = 1$. Hence, the owner's income is expressed as $\pi - \alpha - \beta\pi = -\alpha$; accordingly, $\alpha < 0$. This will be equivalent to the situation where the owner leases the boat to the crew who pay the owner a fixed rent of α for use of the boat. Table 2 summarizes the optimal crew shares for all possible combinations of risk behaviors of the crew and owner.

For the case of the risk-neutral crew, the main concern is the profit level. The owner's optimal strategy is to lease the vessel to the crew and receive a fixed rent (Mas-Colell, Whinston, and Green, 1995). The risk-averse owner is willing to pay a higher portion of the realized profit to the crew in exchange for risk sharing. Accordingly, the share of the profit for the crew is higher under the case of a risk-averse owner than under the risk-neutral owner. Also, given $v'(e^*) = \beta^*$, the more risk averse the owner, the higher is β^* and the higher is the optimal effort level e^* .

Examining the fixed portion of the crew's wage level α , from

$$\alpha^* = v(e^*) + \phi v'(e^*)^2 \sigma^2 - v'(e^*)e^* + \bar{U}$$

we have:

$$(19) \quad \frac{d\alpha^*}{de^*} = v''(e^*) \left[2\phi v'(e^*) - e^* \right].$$

The interrelationships of α^* with β^* and e^* are thus less tractable unless we further assume some specific functional form of $v(e)$.

Empirical Model and Data

Before proceeding to the empirical exercise, we can infer *ceteris paribus* from the profit function $[\pi(e) = e + \varepsilon]$ that the higher the effort level, the higher the profit level. However, the crew's effort is unobservable. Instead, we look at the relationship between the crew's share and profit level. One finding from the theoretical model is that there is a one-to-one positive relation between β^* and e^* : $\beta^* = v'(e^*)$. Accordingly, $e^* = g(\beta^*)$, where $g(\cdot)$ is an inverse function of $v'(\cdot)$. Substituting $e^* = g(\beta^*)$ into the profit function $\pi(e) = e + \varepsilon$, we obtain $\pi(\beta^*) = g(\beta^*) + \varepsilon$. This implies at the equilibrium $d\pi(\beta)/d\beta = g'(\beta^*) = 1/v''(\beta^*)$, which is greater than zero by assumption.

An Empirical Model

This section seeks to empirically check the theoretical prediction of the positive correlation between the crew's share and the vessel's profit. We also investigate the related question—Does a share contract system generate higher economic returns than a flat wage regime? In theory, the share parameter β is a continuous variable ranging from 0 to 1. According to the theoretical model, a higher β corresponds to higher economic returns. Due to the absence of detailed information regarding the crew's share in *ex post* revenue, we consider two cases: the pure fixed wage (i.e., $\beta = 0$) and the share contract (i.e., $0 < \beta < 1$) systems.

Because profit information is not available in our data, we use revenue as a proxy for the profit variable. Also, taking into account the multiple output feature of the longline fisheries, average trip revenue is used as the performance measure (the dependent variable) in this study. Average trip revenue is calculated by dividing the vessel's annual revenue into the number of fishing trips the vessel operated in 2004.⁵ Fishing revenue is postulated to be affected by several factors (explanatory variables) known to have potential impacts on fishing revenue. One such variable is the remuneration method implemented.

To estimate the impact of share contracts on fishing revenue, one may consider using the following model:

$$(20) \quad Y = \mathbf{X}\beta + \delta I + \varepsilon,$$

where Y is the fishing revenue, \mathbf{X} is a vector of explanatory variables, and I is a binary variable indicating whether the vessel employs share contracts or flat wages ($I = 1$ if the vessel uses share contracts, and $I = 0$ if the vessel uses flat wages). However, this model may result in inconsistent estimates from the effect of share contracts on fishing revenue because employing share contracts may generate interaction effects with observed or unobserved vessel characteristics (Maddala, 1983; Kim et al., 1999). For instance, the level of technology of a vessel influences the vessel remuneration methods; yet similarly, the level of technology is correlated to revenue. If the decision to use share contracts is based on individual selection, there may exist selection biases⁶ whereby share contract vessels may have systematically

⁵ We realize that the average profit per trip would provide a more informative measure of crew work effort intensity than the average revenue per trip. Unfortunately, we don't have information on profit. Clearly, the use of revenue as a proxy for profit in our case is less than desirable. Nevertheless, we believe the use of revenue as a proxy can shed some light on crew effort on economic returns in general.

⁶ In theory, the self-selectivity of remuneration regime may exist for both owners and crews. On the one hand, the owner offers compensation conditional on her attributes and expected revenues. On the other hand, the crew determines whether to accept the offer conditional on the crew's attributes and expected revenues. In the context of the Hawaii longline fishery, the majority of crews are foreigners whose main objective is to be employed by a vessel owner, regardless of remuneration practice, to have salary for sending financial assistance back to family at home. Consequently, we can assume that the remuneration choice endogeneity refers to owner's behavior only.

different characteristics from flat wage vessels (Kim et al., 1999). Vessel characteristics may also have different impacts on revenue depending on the type of remuneration. The impact, for example, from hooks per set on revenue for vessels using share contracts may differ from vessels using flat wages.

To correct for these problems, we invoke the switching regression model (Maddala, 1983), which simultaneously estimates the selection equation and two revenue regression equations for share contract and fixed wage vessels. The empirical model follows closely the formulation of Lokshin and Sajaia (2005). To consider a model that describes choosing remuneration systems with two regression equations, we define a criterion function I determining whether or not the vessel employs share contracts:

$$(21) \quad \begin{aligned} I_i &= 1 \text{ if } \gamma' \mathbf{Z}_i + u_i > 0, \\ I_i &= 0 \text{ if } \gamma' \mathbf{Z}_i + u_i < 0, \end{aligned}$$

where $I_i = 1$ if vessel i uses share contracts, and $I_i = 0$ if vessel i uses fixed wages. \mathbf{Z}_i is a vector of variables influencing vessels' contractual choice; \mathbf{Z}_i includes the vessel's current appraised value, the number of hooks used per fishing set, and a binary variable indicating the ease with which the vessel can find local crew. It is expected that the higher the vessel's current appraised value and the higher the number of hooks per set, the less the vessel's revenue depends on the crew and the more likely the vessel's owner will apply fixed wage. Also, given that local crew may be less risk averse than foreign crew, the easier it is for the owner to find local crew and the more likely she will apply a share contract.

The revenue regression equations for share contract and flat wage vessels then can be defined as:

$$(22) \quad y_{1i} = \beta'_1 \mathbf{X}_i + \varepsilon_{1i} \text{ if } I_i = 1,$$

$$(23) \quad y_{2i} = \beta'_2 \mathbf{X}_i + \varepsilon_{2i} \text{ if } I_i = 0,$$

where y_{1i} and y_{2i} are the average trip revenue for share contract and flat wage vessels, respectively. \mathbf{X}_i is a vector of explanatory variables thought to affect vessel revenue, including the current appraised vessel value and the number of hooks used per fishing set.⁷ These two variables represent the technological status of the vessel, and are therefore expected to have a positive impact on the vessel revenue.

Assume also that u_i, ε_{1i} , and ε_{2i} follow a trivariate normal distribution with zero means and the covariance matrix:

$$\mathbf{\Omega} = \begin{bmatrix} \sigma_u^2 & \sigma_{u1} & \sigma_{u2} \\ \sigma_{u1} & \sigma_1^2 & \\ \sigma_{u2} & & \sigma_2^2 \end{bmatrix},$$

where σ_u^2 , σ_1^2 , and σ_2^2 are variances of the error terms in the selection equation (21), the share contract equation (22), and the flat wage equation (23), respectively; σ_{21} and σ_{31} represent the covariances between the error term in the selection equation (21) and the respective error terms in equations (22) and (23).

⁷ In the revenue regression, we include capital and labor as inputs. Note that, in addition to these variables, fish stock and captain's experience are important determinants. We don't have fish stock information in the data. In separate model estimations (not reported here), we included the captain's experience; however, the findings were not significantly different from those reported in this paper. Therefore, we use the current model because it is simpler and yields the same results.

Given these assumptions of the error terms, the logarithmic likelihood function for equations (22) and (23) can be expressed as:

$$(24) \quad \ln L = \sum_{i=1} \left\{ I_i \left[\ln(F(\eta_{1i})) + \ln(f(\varepsilon_{1i} / \sigma_1) / \sigma_1) \right] + (1 - I_i) \left[\ln(1 - F(\eta_{2i})) + \ln(f(\varepsilon_{2i} / \sigma_2) / \sigma_2) \right] \right\}.$$

$F(\cdot)$ and $f(\cdot)$ are the cumulative distribution and the distribution function, respectively; η_{ji} is defined as follows:

$$(25) \quad \eta_{ji} = \frac{(\gamma \mathbf{Z}_i + \rho_j \varepsilon_{ji} / \sigma_j)}{\sqrt{1 - \rho_j^2}}, \quad j = 1, 2,$$

where ρ_1 and ρ_2 are the correlation coefficients of u with ε_1 and ε_2 , respectively.

We are particularly interested in the potential revenue gain/loss in the event a vessel uses an alternative method of remuneration. We expect that the empirical results should yield the differences in vessel revenue when share contract vessels switch to a flat wage system instead, and vice versa. To verify this expectation, the following conditional expectations are constructed:

The conditional expectation of revenue of a vessel using a share contract is written as:

$$(26) \quad E(y_{1i} | I_i = 1, x_{1i}) = x_{1i} \beta_1 + \frac{\sigma_1 \rho_1 f(\gamma \mathbf{Z}_i)}{F(\gamma \mathbf{Z}_i)}.$$

The conditional expectation of revenue of a share contract vessel if it applied flat wage is given by:

$$(27) \quad E(y_{0i} | I_i = 1, x_{1i}) = x_{1i} \beta_2 + \frac{\sigma_2 \rho_2 f(\gamma \mathbf{Z}_i)}{F(\gamma \mathbf{Z}_i)}.$$

The expected potential gain/loss of a share contract vessel if it applied flat wage is represented by:

$$(28) \quad E(y_{0i} | I_i = 1, x_{1i}) - E(y_{1i} | I_i = 1, x_{1i}).$$

Similarly, the conditionally expected revenue of a flat wage vessel if it applied a share contract is specified as:

$$(29) \quad E(y_{1i} | I_i = 0, x_{2i}) = x_{2i} \beta_1 - \frac{\sigma_1 \rho_1 f(\gamma \mathbf{Z}_i)}{1 - F(\gamma \mathbf{Z}_i)}.$$

The conditional expectation of revenue of a vessel using flat wage is:

$$(30) \quad E(y_{0i} | I_i = 0, x_{2i}) = x_{2i} \beta_2 - \frac{\sigma_2 \rho_2 f(\gamma \mathbf{Z}_i)}{1 - F(\gamma \mathbf{Z}_i)}.$$

Finally, the expected potential gain/loss of a flat wage vessel when applying a share contract instead is expressed as:

$$(31) \quad E(y_{1i} | I_i = 0, x_{2i}) - E(y_{0i} | I_i = 0, x_{2i}).$$

Data

Data collected and used for this study are taken from the 2004 Hawaii-based Longline Technology Survey (HLTS), which provides baseline fishing technology information and some economic information on the Hawaii-based domestic longline fleet. The unit of survey is an individual longline vessel, with a total of 86 surveyed vessels. Traditionally, the Hawaii longline fisheries include both tuna and swordfish. However, the HLTS focused only on the tuna fishery, due to the late reopening of the swordfish fishery in 2004.

The survey questionnaire included two main sections. The first requested key information on the number of crew, remuneration method, and fishing experience of the captain. The second section focused on the technology on board the vessel—a list of all electronic equipment (e.g., satellite communication system, computers, etc.), dates when each piece of technological equipment was adopted, and the purchase price of each piece of equipment. The appraised current vessel value was used as a proxy for the overall technological status of the vessel. We note that the appraised value might not be a good indicator of technology because it accounts for depreciation. For instance, if there are two vessels with exactly the same equipment but with different vessel age, their appraised values may differ but their technologies are the same. With this in mind, we ran econometric models controlling for the vessel's age; however, the findings were not significantly different from those reported here.

Because the HLTS did not survey vessel revenue information, two other sources of data were employed in this study. The first data set, from the Hawaii Division of Aquatic Resources (HDAR), provided detailed information in 2004 on each vessel's catch, by species, with its corresponding auction price. Based on this information, the vessel's annual revenue was estimated as well as the total number of fishing trips taken during that year. The second data set, from logbook data provided by the National Marine Fisheries Services, contained detailed information on the quantity of fish (by species) landed and kept per vessel. These three data sets were linked using vessel names and permit numbers. The combined data are used for the empirical exercise.

Table 3 presents three key relationships between vessel characteristics and remuneration regime found in the combined data. First, if the vessel crew size is larger than five, there is a high probability vessels will use a fixed wage regime. However, vessels using hired captains rather than those with owner-operators have a higher probability of adopting a share contract regime. Third, if it is easy to find the crew, there is a high probability that vessels will employ a share contract.

Model Specification

There are two important variables used in the analysis: remuneration choice and average revenue per trip. The remuneration choice (binary) variable equals 1 if there is at least one crew member hired by share contract in addition to the captain, and 0 otherwise.⁸ These two variables form the foundation for the estimation procedures. Appendix table A1 briefly defines all the variables used in the empirical model.

⁸ In actuality, the remuneration system used among Hawaii longline fishing boats is a bit more complex than what we are assuming here. Some vessels had split crews such as a Vietnamese captain, first mate, and cook (who all fished, too), and a crew of foreign workers (e.g., Filipinos, Micronesians, etc.). The captain, first mate, and cook were paid on share contract and the foreign crew by fixed wage.

Table 3. Main Vessel Characteristics by Remuneration Regime

Vessel Characteristic	Share Contract (%)	Flat Wage (%)
<i>Number of Crew:</i>		
Equal to 5	47.9	52.1
Less than 5	87.5	12.5
Greater than 5	45.4	54.6
<i>Owner-Operator:</i>		
Yes	48.7	51.3
No	59.2	40.8
<i>Difficulty in Finding a Local Crew:</i>		
Very difficult	45.4	54.6
Not much	74.0	26.0
<i>Number of Vessels</i>	55	45

As part of the switching regression procedure, a probit model is used to investigate the determinants of employing share contracts in the Hawaii longline fisheries. There are two sets of independent variables. The first set includes all explanatory variables in the revenue regression equations. Such inclusion takes into account the fact that fishing revenue also has an impact on the owner's decision to use share contracts. Owners will be more likely to employ a share contract if it results in higher revenue than the flat wage. Hence, factors that have an impact on revenue may also have correspondingly similar impacts on the remuneration choice. Also, Wooldridge (2004a) notes that including the second stage's variables in the first stage makes the estimations consistent, and is not very costly.

The second set of independent variables in the share contract equation aims at satisfying the identification condition. Nonlinearity is not sufficient to meet the identification condition; rather, additional identifying variables are added in the first equation. These variables are not included in the revenue equations. Bound, Jaeger, and Baker (1995) caution that the use of weak instruments is problematic since the potential bias does not disappear even in a large sample. Given the small sample size of our data, it is even more crucial to choose good instruments. We also follow Wooldridge (2004b) by not using any interaction term to limit the number of over-identifying restrictions. In particular, we include three instrumental variables: (a) a binary variable representing the ease with which owners find crew,⁹ (b) the ethnicity of the vessel owner, and (c) a binary variable indicating whether the captain is also the vessel owner. These variables do not significantly impact vessel revenue, but rather have a significant impact on the owner's decision to use share contracts.

In addition to share contracts, other potential determinants of fishing revenue were integrated into the model. We make use of the vessel's width as a proxy for the size of the vessel. The number of fishing hooks used per set was included as a proxy to measure the utilization of a vessel's potential fishing capacity. The more hooks used per set, the more a vessel could utilize its fishing capacity potential. The number of crew served as a proxy for the vessel's human resources. The size of the crew is expected to have a positive correlation with the vessel revenue.

⁹ In the 2004 Hawaii-based Longline Technology Survey (HLTS), there is one question asking how easy it is for the owner to find local crew. We use this information to generate the corresponding binary variable.

Table 4. Mean Comparisons by Main Characteristics of Vessels

Vessel Characteristic	Total Sample [1]	Share Contract [2]	Flat Wage [3]	<i>p</i> -Value [2]–[3]
Vessel's trip revenue (\$)	31,295	30,714	31,920	0.730
Vessel's appraised current value (\$)	428,116	456,316	393,548	0.130
Caucasian owner	37	24	13	
Korean owner	29	12	17	
Vietnamese owner	20	11	9	
Time crew working together (years)	0.5	0.5	0.5	0.460
Hooks per set	1,945	1,924	1,968	0.720
Vessel's width	21.15	20.58	21.83	0.055*
Ease in finding local crew (easy = 1)	0.36	0.47	0.23	0.010***
Number of crew	5.12	4.90	5.30	0.005***

Notes: Single, double, and triple asterisks (*, **, ***) denote statistical significance at the 10%, 5%, and 1% levels, respectively. The *p*-values are based on a one-tailed *t*-test.

Table 4 shows a comparison of descriptive statistics between share contract and fixed wage vessels. As observed from table 4, fixed wage vessels outperform share contract vessels in terms of revenue. Share contract vessels have higher appraised current value, whereas flat wage vessels utilize more hooks per set. This contrast highlights different strategies to improve total revenue. Share contract vessels focus on technological investments, while flat wage vessels emphasize increasing the number of hooks used per set. These differences are, however, insignificant. The significant difference of greatest interest is the ease in finding local crew. As expected, it is much easier for share contract vessels to find local crew than it is for fixed wage vessels.

Main Empirical Results

Table 5 presents the determinants of the share contract decision. One of the key factors in determining remuneration regimes is the ease of finding a local crew. The easier it is for the owner to find a local crew, the more likely she prefers using share contracts. This finding reflects present circumstances within the Hawaii longline fisheries. As owners experience a shortage in the supply of local fishermen, owners must depend on a third party to find foreign crew. As implied by our theoretical model [and consistent with the McConnell-Price (2006) model], it might be in the owner's interest to use fixed wages given the high level of risk aversion among foreign crew.

Vessels with larger crews also prefer flat wages over share contracts, possibly because of the trade-off between the quality and quantity of the crew. It is likely that vessel owners of large crew do not place much emphasis on the marginal productivity of each crew member, which is hard to identify. Meanwhile, owners with a small number of crew may believe in the quality of crew, and thus use a share contract as a mechanism to increase marginal productivity of each crew member.

Table 5. Determinants of Share Contract Decision

Vessel Characteristic	Coefficient	Standard Error
Number of hooks per set	0.000	0.001
Number of crew	−0.526**	0.268
Width of vessel	−0.064	0.053
Easy to find local crew (1 = yes, 0 = no)	0.371*	0.202
Korean vs. Caucasian vessels	0.076	0.428
Vietnamese vs. Caucasian vessels	0.254	0.511
Owner-operated vessels	0.018	0.308
Constant	2.938*	1.687
No. of observations = 77		

Note: Single, double, and triple asterisks (*, **, ***) denote $p < 0.10$, 0.05, and 0.01, respectively.

The effect of a vessel's characteristics on its fishing revenue is different between share contract and flat wage vessels (table 6). The number of hooks per set has a significant impact on fishing revenue only for share contract vessels. The effect of the vessel's width (which is a proxy for the vessel's size) on fishing revenue is consistently significant in these two groups of vessels—both remuneration strategies produce higher economic returns in the larger vessels. Interestingly, the estimated coefficient for the share contract equation is greater than that for the flat wage equation, which implies share contract vessels may make more efficient use of vessel size than their flat wage counterparts. Concerning the effect of the crew size on revenue, the more crew members there are, the higher is the revenue realized. However, this effect is significant only among the share contract vessels. This result is consistent with our discussion above regarding the trade-off between quality and quantity of crew. It is likely that share contract vessels place more emphasis on the quality of crew; therefore, an increase in the number of crew among share contract vessels leads to more significant improvement in revenue compared to flat wage vessels.

The estimated correlation coefficients ρ_1 and ρ_2 between the error term in the selection equation and the error terms in the share contract and flat wage revenue equations reveal any selection bias in the share contract decision ρ_1 is statistically significant, but ρ_2 , though it is negative, is insignificant. Given both ρ_1 and ρ_2 are negative, one can infer that the flat wage vessels may have an “absolute advantage”—i.e., flat wage vessels would have above-average performance whether they chose to use share contract or not. In this case, share contract vessels have below-average performance whether they chose to use share contract or not. In other words, the flat wage vessels are generally better fishers.

Having estimated the parameters of the switching regression models, we can calculate the expected gains and losses from counterfactual revenue differences [equations (28) and (31)]. These results will show whether it is economically beneficial for the share contract vessels to employ flat wages, and conversely whether it is better for the flat wage vessels to employ share contracts.

Table 7 reports the differences between the expected revenue of the counterfactual and expected revenue of the actual. The counterfactual is defined as the expected revenue a share contract (flat wage) vessel would have generated if it had used flat wages (share contracts).

Table 6. Parameter Estimates of the Revenue Equations

Vessel Characteristic	Share Contract		Fixed Wage	
	Coefficient	Std. Error	Coefficient	Std. Error
Number of hooks per set	12.563***	3.419	2.350	4.311
Number of crew	4,027**	1,849	1,104	2,472
Width of vessel	1,176***	406	970***	373
Constant	-3,372***	1,067	-803	22,001
ρ_1	-0.813**	0.345		
ρ_2	-0.221	1.217		

Note: Single, double, and triple asterisks (*, **, ***) denote $p < 0.10$, 0.05, and 0.01, respectively.

Table 7. Counterfactual versus Expected Revenue

Vessel RemunerationType	Difference Between Counterfactual and Expected Actual Revenue		p -Value
Share contract	-3,141**		0.01
Flat wage	12,350***		0.00

Note: Double and triple asterisks (**, ***) denote statistical significance at the 5% and 1% levels, respectively.

A key conclusion is that flat wage vessels would markedly increase their revenue margins if they applied share contracts. This finding has significant implications for the Hawaii longline fisheries, as more share contract vessels have recently switched to the use of flat wages. A major reason for this change is that foreign crew are currently the main source of fishermen in Hawaii. Foreign crew may be more risk averse than local crew because of their dependence on fishing as a sole source of income. As implied by the theoretical model, it is optimal for the owner to use flat wage in the case of very risk-averse crew. Yet, not all foreign crew are very risk averse; some of them may even be risk neutral or risk preferring. Under such circumstances, it might be more beneficial for the owner to adopt a share contract. Put concisely, a more flexible remuneration system may be better than a pure fixed wage regime. This finding corroborates results reported by Eriksson, Teyssier, and Villeval (2006) who found that workers would exert more effort if they had the flexibility of choosing the remuneration practice in accordance with their risk preference.

Policy Implications

It is an interesting exercise to investigate how rights-based management of the fishery, especially the shallow-set certificate program, might affect the type of crew remuneration regime. In the context of our study, it is worth noting that the shallow-set certificate program is more applicable to swordfish in the Hawaii longline fishery than to the tuna fishery in which the deep set is used. Also, after having been closed in Hawaii for two years, the sword-

fish fishery was reopened in 2004 under a “set cap” program. Given this special feature of Hawaii’s swordfish fishery, our data include information on the tuna fishery only, which had no quota program as of 2004.

Despite the above limitation, our findings still offer some relevant policy implications for Hawaii fisheries in which more focus is given to rights-based fishery management. In particular, under the quota system, the owners may find it beneficial to increase the labor intensity of the active crew without too much compensation to the crew in order to make the best use of the quota (Guyader and Thebaud, 2001). As such, the owners may prefer the fixed wage over the share contract since the former allows the owners to increase the length of fishing trips by paying the same amount of monthly wage to the crew.

A number of other studies also show that the quota system may lead to reduction in the share for crew. For instance, according to Squires, Kirkley, and Tisdell (1995, p. 153):

Wages to crew may change if owners readjust the share system to enhance their profit or to maintain their position within this increasingly competitive industry or to account for the cost of purchased quotas.... Returns to crew may fall if crew-share agreements change to reflect the cost of obtaining ITQs and the opportunity cost of using them.

Conclusions

This paper attempts to systematically answer the question: “Why is the share contract regime the optimal form of remuneration in the fisheries sector?” By focusing on the Hawaii longline fisheries, where flat wage has recently become the preferred mode of remuneration, we have a strong case to test this theoretical prediction. Using the principal-agent approach, we develop a simple and comprehensive model that takes into account the roles of both incentive and risk behavior to explain the underlying mechanism of remuneration choice in fisheries. Our model suggests there is a trade-off between incentive and risk aversion. The more risk averse is the crew, the less incentive will be brought about by the contract. Accordingly, it might be optimal for the owner to use fixed wage under certain circumstances. As in the case of Hawaii’s longline fisheries, one of the primary reasons for the substitution of fixed wage for share contract has been the lack of local crew members keeping longlining as their primary occupation. As a result, the vessel owner is constrained to hire foreign crew who are more risk averse than local crew. The high level of risk aversion among foreign crews is likely one of the key reasons for the recent observed move to fixed wage in remuneration practice.

Empirically, this is one of the first studies to investigate the impact of share contracts on fishing productivity. Results of the counterfactual simulations reveal that vessels employing flat wages would produce higher fishing revenues if they were to adopt a more flexible remuneration system that best fit the crew’s risk behavior, rather than a pure fixed wage regime. More specifically, it may be better for the Hawaii longline fleet if foreign crews have the opportunity to choose a remuneration scheme that fits their risk behavior rather than letting the remuneration strategy be solely determined by the vessel owners.

Our model shows that risk behavior of the crew and owner plays an important role in deciding how large the optimal revenue-sharing parameter β should be. This investigation could have yielded more profound findings if data on risk preferences had been available. A promising extension of the study would be to conduct an experiment on risk preferences among crew and owners in Hawaii’s longline fishery. The resulting experimental data could then be combined with data used here.

We note several limitations of this study. First, the theoretical model investigates the relationship between risk aversion of the owner and crew and choice of remuneration. However, the current data set does not contain measures of “risk aversion” for either party. Conducting a field experiment on risk preferences of Hawaii longline fishermen would be a worthwhile extension. Second, we do not have the data for specific values of the share parameter β ; thus, instead of treating β as a continuous variable, we simply treat it as a binary variable. The theoretical model predicts that the greater the percentage of the crew share, the higher will be the vessel revenue. It would be useful to explore how a change in the shared revenue portions impacts revenue margins.

Along this line, an interesting policy dimension¹⁰ of this work would be an assessment of how rights-based management of the fishery might affect the type of crew remuneration regime. Of particular interest here would be the impact of the annual cap on aggregate longline sets in the Hawaii-based shallow set longline fishery on the form of crew remuneration regime. The total allowable sets are allocated to the vessels permitted to operate in the fishery in the form of tradable set shares. Tradable set shares are a component of a regulatory package designed to limit turtle takes in the fishery. A side effect of this policy would be the impact on risk associated with exclusive access to the target stocks. For example, one might hypothesize that given this right, risk associated with open access would be greatly reduced—in which case there likely would be a greater use of the flat wage crew remuneration regime. In terms of future investigations, this study could be enhanced by considering the impact of this particular policy, or alternative rights-based conservation and management approaches, on aggregate employment and profitability in the fishery.

There are also a number of interesting facets of remuneration in Hawaii longline fisheries that offer grounds for future investigation. First, foreign crew and local crew may consist of different labor qualities. These differences in quality may have an impact on an owner’s decision regarding remuneration strategies. An owner, for example, may be more inclined to use share contracts with high-quality labor. Further studies of the determinants that influence labor quality can be a fruitful area for future research. Second, the Hawaii longline fisheries consist of three ethnicities of vessel owners, which imply different decision-making behaviors. Asian owners, for example, might prefer share contracts that promote cooperation. Examining the effect of ethnicity on remuneration choice is a topic of great relevance. Finally, an owner with a fleet of vessels may prefer to apply the same kind of remuneration on all of her boats. Given that it is not uncommon for an owner to possess multiple boats in the Hawaii longline fisheries, another potential extension of this paper would be to explore how this feature influences the use of a particular remuneration strategy.

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¹⁰ We are grateful to a referee for pointing out this important dimension of the study.

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Table A1. A Brief Definition of Variables in the Empirical Model

Variable	Definition
Share contract	Binary variable: = 1 if vessel applies share contracts, = 0 if vessel applies flat wages
Vessel's trip revenue	Average revenue of vessel per trip
Vessel's appraised current value	Estimated value of the vessel
Owner ethnicity	Ethnic traits of vessel owner: 1 = Caucasian, 2 = Korean-American, 3 = Vietnamese-American
Time crew working together	Years the same crew spent working together
Hooks per set	Average number of hooks used per fishing set
Ease in finding local crew members	How easy is it to find a local fisherman? 1 = easy, 0 = otherwise